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Firm value and government commitment to combating climate change

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1. Introduction

Under President Donald Trump's leadership, the U.S. government has made efforts to roll back policies aimed at reducing carbon-dioxide emissions. This decrease in government commitment to combating climate change is counter to the growing concern about climate change and pressure from shareholders for companies to account for climate risks in their strategies. Climate change and carbon emissions are becoming "the most significant overall environmental factor" for socially-minded investors in the U.S. (Chandler, 2017; Gsia, 2015). During 2015, this concern affected $2.15 trillion in institutional investor assets, which was a 17% increase over 2014.[1]

The level of governmental commitment to climate change is related to the probability that firms will face increased regulatory costs. Direct regulatory costs include fines, required participation in emissions trading markets, and installation of required pollution control equipment. Indirect costs related to government commitment include voluntary investment to configure supply chains and production processes to avoid increased regulatory costs, for example, investing in cleaner production methods or switching to renewable fuels to reduce carbon emissions. Assuming that greater governmental commitment translates into increased regulatory costs, the stock market may respond positively (negatively) to decreases (increases) in commitment. Further, the degree of stock market response should be related to the firm's level of climate risk, since any restrictions resulting from government policy should have the most impact on companies with the highest climate risk exposure.

We use event-study methodology to examine the impact of government commitment to combating climate change on firm value.

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[1] See http://greenmoneyjournal.com/major-sri-drivers-and-trends-from-the-sri-trends-report

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We examine several exogenous shocks (events) to address this question. In the U.S., the surprise election of Donald Trump as president, his choice of a climate change denier as Administrator of the Environmental Protection Agency (EPA), and announcement of budget cuts for the EPA are all signals of a reduction in U.S. government commitment to addressing climate change. This is in contrast to events prior to his election. Based upon passage of the Paris Climate Change agreement and President Obama's support for the agreement, it appeared that the U.S. government was increasing its commitment to combating climate change. Together, these events represent changes in commitment by the U.S. government, providing a strong setting to explore the impact on firm value of expected regulatory costs related to climate change as a function of firms' exposure to climate risk.

Because we study clustered events that affect the sample firms at the same moment in time, we use portfolio time-series regression event-study methodology to address cross-correlation in the abnormal returns. Portfolio time-series regressions provide unbiased estimates of the coefficients, along with standard errors that fully account for cross-sectional heteroskedasticity and cross-security dependence (see Sefcik and Thompson, 1986). We implement a portfolio time-series approach by forming portfolios that take a long position in firms with a high exposure to climate risk and a short position in firms with low exposure to climate risk. We refer to these portfolios as "climate risk hedge portfolios".

We hypothesize that government commitment to combating climate change has an impact on the expected costs faced by firms related to their climate risk. We expect that firms with high climate risk will face lower expected regulatory costs when the government becomes less committed to combating climate change. Since Trump had signalled during the campaign that he would withdraw from the Paris agreement on Climate Change,[2] his surprise election would have been perceived as signalling a reduction in commitment. We anticipate that for such an event, the market value of firms with high climate risk increases relative to the value of firms with low climate risk. In other words, after controlling for other firm attributes that are likely to affect returns, we expect our climate risk hedge portfolio to have positive abnormal returns in the period around the election. For events that signal an increase in commitment, such as the initial passage of the Paris agreement, we expect the opposite; our climate risk hedge portfolio should have negative abnormal returns around the event. We also test if the market was surprised by the actual actions of the new Trump government, subsequent to his inauguration on January 20, 2017. Given the general perception that the Trump administration reduced its commitment to combating climate change more than anticipated, we predict a further increase in the value of firms with high climate risk relative to firms with low climate risk.[3]

It is possible that there is no change in the value of our climate risk hedge portfolio around our main events, however. For example, it could be the case that shareholder pressure forces firms to take climate change into account irrespective of government policies. Firms might also voluntarily change to renewable energy if it is a cheaper source of electricity than traditional fossil fuels, which, according to the International Renewable Energy Agency (IRENA) is expected to happen by 2020.[4] Further, it is possible that new or existing environmental rules and regulations at the state- or city-level fully substitute for rules and regulations at the federal level.[5] In this case, changes in the level of federal government commitment might have no or only limited impact on firm value. We develop separate hypotheses and related tests to explore this possibility.

Berkman et al. (2018) employ a measure of firm-specific exposure to climate risk based on textual analysis of 10-K disclosures. As hypothesized, the measure of climate risk is negatively associated with firm value. We use this firm-specific measure of climate risk exposure to form different portfolios: i) US firms with high exposure to climate risk; ii) US firms with low exposure to climate risk; iii) non-US firms listed in the US with high exposure to climate risk; and iv) non-US firms listed in the US with low exposure to climate risk. The latter two portfolios allow us to control for firms that face similar market conditions but are not subject to US climate-related regulation. We also explore the impact of state- or city-level regulation by focusing on a climate risk hedge portfolio of firms that are domiciled in California versus a climate risk hedge portfolio of firms domiciled outside of California. This latter contrast allows us to test whether state- or city-level regulations can substitute for federal level regulations, since California has the most stringent environmental regulations of any state. Further, in reaction to the Trump government's reduced commitment to combating climate change, California state officials explicitly announced they would continue to work toward meeting targets of the global climate accord.[6]

For each test, we define the return on the climate risk hedge portfolios as the difference in the value-weighted return on the appropriate portfolio of firms with high climate risk and the value-weighted return on the portfolio of firms in the sample with low climate risk. We find that for US firms, there is a significant −0.5% abnormal return for our hedge portfolio around signing of the Paris agreement, a significant 1% abnormal return around the election of President Trump and a further positive abnormal return of around 4% following his inauguration.

The hedge portfolio comprised of non-US firms also experienced a negative return around the signing of the Paris agreement. This is consistent with the international nature of the agreement. However, unlike the hedge portfolio for US firms, there was no reaction to the US-specific election outcome and a relative value *decrease* in reaction to US policies announced in the first 6 months of the Trump administration. In our test for local government influence on the impact of federal level commitment to addressing climate change, we find that the Californian and non-Californian climate risk hedge portfolios have similar reactions to the signing of the

[2] See http://www.cbc.ca/news/politics/trump-scrap-paris-climate-deal-1.3835616.

[3] See, for example, https://www.theguardian.com/environment/climate-consensus-97-per-cent/2018/feb/01/its-not-okay-how-clueless-donald-trump-is-about-climate-change

[4] https://www.forbes.com/sites/dominicdudley/2018/01/13/renewable-energy-cost-effective-fossil-fuels-2020/#7d2c55274ff2

[5] See http://www.latimes.com/politics/la-na-pol-paris-states-20170602-story.html.

[6] See http://www.aljazeera.com/indepth/features/2017/06/trump-ditches-paris-california-leads-environment-170625141250430.html

Paris agreement and the election of Trump. However, while the Californian hedge portfolio has an (insignificant) value *decrease* in the first 6 months after the inauguration, the non-Californian hedge portfolio has a significant value *increase* during that period. This result is consistent with the idea that local regulations can supplant action at the Federal level.

Our research builds on a stream of literature linking accounting disclosure to stock prices starting with Ball and Brown (1968) and Beaver (1968) and more recent evidence on the value relevance of mandatory risk disclosures (Campbell et al., 2014). Our study also contributes to the literature on the value impact of regulation (e.g., Larcker et al., 2011) and market expectations about enforcement of new regulations (e.g., Berkman et al., 2010). In reaction to three exogenous shocks in the level of government commitment to combating climate change, we show significant changes in the stock market valuation of firms with high exposure to climate change relative to firms with low exposure to climate change.

Finally, we contribute to the literature on climate change and provide evidence that the Ceres/CookESG climate risk measure is a useful summary measure of firm-specific climate risk that helps to explain variation in market valuations across firms (Berkman et al., 2018).

2. Sample selection, climate risk variable definition, and descriptive statistics

2.1. Sample selection and climate risk variable definition

Our sample is based on the companies included in the CERES database, which is comprised of Russell 3000 firms with 10-K filings and foreign firms listed in the US with 20-F filings.[7] As described in Berkman et al. (2018), the CERES climate risk measure is based on textual analysis of extracts in 10-K disclosures that describe different aspects of climate risk.[8] This firm specific measure is a function of both the length of climate change related disclosures in company 10-Ks and the specificity of the language used, where language that is more directly relevant to climate risk is scored higher than language that is only indirectly relevant. The firm-specific measure of climate change exposure used in this study is based on our sample firms' 10-Ks reported during calendar year 2015.

Individual stock returns, share prices and number of shares outstanding are from CRSP. We obtain factor returns and the Fama and French 48 industry classification from Kenneth French's website.[9] Our US sample includes 2990 firms, all of which are in the Russell 3000 index. California-domiciled firms comprise 461 observations. Our non-US sample includes 678 firms.

2.2. Descriptive statistics

Table 1 presents an overview of our base measure of climate risk exposure (*ClimateRisk)* across industries according to the Fama-French 48 industry classification. The largest industry representation is for firms in business services (12% of all firm-year observations). For this industry, climate risk is not ubiquitous, with a median value of 0. Unsurprisingly, firms in industries that have been traditionally viewed as "dirty," including the coal, utilities, and petroleum and natural gas industries have a high average climate risk score. These three industries comprise about 7% of total firm-year observations in our sample. However, climate risk appears to affect all industries; each of the 48 industries represented in our sample includes firms that report some aspect of material climate risk. The smallest average climate risk scores per industry are within the pharmaceutical, printing and publishing industry, defense, and medical equipment industries. These industries comprise about 13% of total firm-year observations in our sample.

3. Methodology

Since all sample firms are affected by the same event at the same time, the non-zero cross-correlation between firms' abnormal returns invalidates the use of a simple regression analysis, whereby the abnormal returns of individual stocks are regressed against a set of explanatory variables including, *ClimateRisk*. To address this clustering problem, Schwert (1981) and Campbell et al. (1997) recommend using a portfolio approach, in which firms are grouped into portfolios. We follow their recommendation and form our portfolios as follows. For each of the 48 Fama-French industries, we select the one-third of companies with the highest climate risk exposure for inclusion in the long portfolio and for each of the 48 Fama-French industries we select the one-third of companies with the lowest climate risk exposure for inclusion in the short portfolio. Both the long and short portfolio are value-weighted to reflect the economic significance of the firms in each portfolio. To evaluate the performance of this hedge portfolio around the main events, we use the four-factor model as the benchmark. We also present results using CAPM and the Fama and French three-factor model as benchmarks.

Let HIGH denote the portfolio of firms that are in the top tercile of each industry in terms of their climate risk exposure, and LOW the portfolio of firms that are in the bottom tercile of each industry in terms of their climate risk exposure. We run the following regression on the daily hedge portfolio returns over a two-year period starting on 1 June 2015 and ending on 30 June 2017, comprising 526 trading days:

[7] See https://www.ceres.org/resources/tools/sec-sustainability-disclosure-search-tool.

[8] The climate risk data are available on the Ceres website (http://www.ceres.org/resources/tools/sec-climate-disclosure/sec-climate-disclosure). For details we refer to Berkman et al. (2018) in particular Appendix A.

[9] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

Table 1
Frequency and summary statistics of climate risk score by industry.

Industry classification	*N*	Mean	Median	STDEV	Min	Max
Agriculture	9	19	19	19	0	51
Aircraft	17	4	0	6	0	16
Apparel	28	6	4	6	0	17
Automobiles and trucks	47	10	4	18	0	97
Banking	281	2	0	4	0	35
Beer & liquor	9	17	20	18	0	50
Business services	349	2	0	7	0	65
Business supplies	26	17	2	29	0	104
Candy & soda	7	23	25	15	0	41
Chemicals	57	32	18	37	0	157
Coal	5	214	239	90	125	338
Communication	78	2	0	4	0	16
Computers	68	2	0	5	0	33
Construction	44	21	13	24	0	101
Construction materials	48	21	9	38	0	180
Consumer goods	34	7	0	18	0	102
Defense	8	1	1	2	0	4
Electrical equipment	37	12	4	25	0	110
Electronic equipment	141	7	0	34	0	394
Entertainment	36	10	7	12	0	57
Fabricated products	6	12	6	14	0	33
Food Products	45	17	13	16	0	70
Healthcare	38	4	0	8	0	42
Insurance	77	21	6	28	0	104
Machinery	89	13	4	23	0	144
Measuring and Control Equip.	43	3	0	7	0	42
Medical Equipment	83	1	0	3	0	20
Non-Metallic and Metal Mining	15	51	34	45	0	147
Personal Services	34	3	0	6	0	24
Petroleum and Natural Gas	118	90	87	59	0	341
Pharmaceutical Products	280	1	0	4	0	48
Precious Metals	7	21	13	28	0	82
Printing and Publishing	18	1	0	2	0	10
Real Estate	19	12	5	16	0	47
Recreation	11	2	0	5	0	16
Restaurants, Hotels, Motels	56	9	8	8	0	35
Retail	144	9	5	14	0	109
Rubber and Plastic Products	14	5	3	5	0	18
Shipbuilding, Railroad Equip.	9	9	10	9	0	26
Shipping Containers	9	14	12	12	2	37
Steel Works etc	28	28	18	42	0	188
Textiles	7	6	5	6	0	18
Tobacco Products	2	9	9	4	6	12
Trading	241	7	0	17	0	201
Transportation	81	34	28	30	0	135
Utilities	85	126	106	108	0	687
Wholesale	79	14	5	25	0	136
Other	23	57	14	84	0	265
Total	2990					

Notes: Table 1 presents summary statistics for the full sample of firm-year observations across the Fama-French 48 Industry Classification.

$$R_{HIGH,t} - R_{LOW,t} = \alpha + \beta_1 MKTRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \beta_5 ParisIN(-1,1) + \beta_6 Election(-1,1) + \beta_7 Inaguration/ParisOUT(-93,1) + \varepsilon_t \quad (1)$$

where R_{HIGH} is the day t value-weighted return on the portfolio HIGH and R_{LOW} is the day t value-weighted return on portfolio LOW. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. We are mainly interested in the abnormal return of the hedge portfolio during the following event windows (*Events*):

1) a three-day window (t-1 to t + 1) surrounding adoption of the Paris climate agreement by the Conference of the Parties of the United Nations Framework Convention on Climate Change on 12 December 2015 (day 0, event 1), *ParisIN*;

Table 2
Regression results for the daily hedge portfolio based on climate risk measure.

	(A)		(B)		(C)	
	Market model		*FF3*		*FF4*	
	Est.	*p*-value	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.91	0.000	0.92	0.000	0.97
ParisIN	−0.004	0.11	−0.004	0.06	−0.005	0.03
Election	0.008	0.01	0.012	0.01	0.012	0.01
Inauguration/ParisOUT	0.044	0.01	0.030	0.06	0.033	0.03
MKTRF	−0.059	0.01	−0.049	0.01	−0.039	0.01
SMB			−0.061	0.01	−0.043	0.01
HML			−0.092	0.01	−0.062	0.01
MOM					0.056	0.01
Adj R2	0.079		0.162		0.208	

Notes: Table 2 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the one third of companies with the highest climate risk exposure for each of the Fama-French 48 industries and a short position in the one third of the companies with the lowest climate risk exposure portfolio for each of the 48 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Panels A-C, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

2) a three-day window (t-1 to $t + 1$) around the surprise election of Donald Trump as President of the United States on 8 November 2016 (day 0, event 2), *Election*; and.
3) a long event window of 93 trading days from the day before Trump's inauguration on 20 January 2017 (day -93, event 3) through 2 June 2017, one day after the formal withdrawal from the Paris agreement (day 1, event 3), *Inauguration/ParisOUT*.

The events are accounted for by the variables *ParisIN*, *Election*, and *Inauguration/ParisOUT, and* are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The coefficients $\beta_5 \beta_6$ and β_7 represent the cumulative abnormal return of the hedge portfolio around these three climate change events.

Note that our selection of stocks to be included in the high and low climate risk portfolios is on an industry-by-industry basis. While this approach might be desirable in general, there was likely a large, non-climate risk-related impact of Trump's election on specific industries. For example, pharmaceuticals experienced a sharp increase in value following the election because, unlike Hillary Clinton, Trump's stated drug price policies (and eventual 2017 regulations) were aimed at reducing payments to hospitals and subsidies to patients, but were in favour of the pharmaceutical companies (Johnson, 2017). This policy implication is unrelated to Trump's climate policy, but is clearly a positive for pharmaceuticals, which score low on climate risk exposure (see Table 1).

4. Main results

The first test examines the performance of the portfolio that has a long position in the one third of companies with the highest climate risk exposure for each of the Fama and French 48 industries and a short position in the one third of the companies with the lowest climate risk exposure portfolio for each of the 48 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Table 2, Panels A-C, respectively.

Results in Table 2 are generally consistent with our expectations. The Paris Agreement on Climate Change (*ParisIN)* resulted in a decrease in the value of firms with a high score on climate change exposure ("polluters") versus firms in the same industry with a low score on climate change exposure ("non-polluters"). The total cumulative abnormal return on the climate risk hedge portfolio during the 3-day window is around −0.4 to −0.5% depending on the factor model used, with *p*-values ranging from 0.11 for the market model to 0.03 for the four-factor model. The unexpected election of Donald Trump as president of the U.S. (*Election)* resulted in a significant value increase for polluting firms relative to same-industry non-polluters of around 1% (*p*-value for all models is 0.01). The period between the inauguration through to the withdrawal from the Paris agreement (*Inauguration/ParisOUT)* saw a further increase for polluters relative to same-industry non-polluters of around 3 to 4%, with *p*-values for the cumulative abnormal return ranging from 0.01 to 0.06. This last result is consistent with our conjecture that the market was surprised by the extent to which the Trump government delivered on its promises to roll back Obama-era policies that aimed to curb climate change and limit environmental pollution.

Our second test examines the performance of the climate risk hedge portfolio for the firms in our sample head-quartered in California versus all other US firms in our sample. The results for firms domiciled in California are in Panel A in Table 3 and the

Table 3
Regression results for the daily hedge portfolio based on climate risk measure for firms head-quartered in California versus all other US firms.

	(A)		(B)	
	California		*Non-California*	
	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.21	0.000	0.66
ParisIN	−0.010	0.01	−0.004	0.09
Election	0.008	0.01	0.013	0.01
Inauguration/ParisOUT	−0.013	0.79	0.039	0.02
MKTRF	−0.001	0.98	−0.050	0.01
SMB	−0.072	0.18	−0.040	0.02
HML	−0.236	0.01	−0.033	0.13
MOM	0.203	0.01	0.037	0.01
Adj R2	0.206		0.145	

Notes: Table 3 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the one third of companies with the highest climate risk exposure for each of the Fama-French 48 industries and a short position in the one third of the companies with the lowest climate risk exposure portfolio for each of the 48 Fama-French industries. Panel A and Panel B present the results for the four factor model for firms head-quartered in California and rest of US listed firms in our sample, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

results for the US firms domiciled outside of California are in Panel B in Table 3.[10]

The hedge portfolio cumulative abnormal returns around the signing of the Paris agreement and the election are similar for firms headquartered in California and firms outside of California. However, the value change subsequent to the inauguration of the Trump government is markedly different between the two samples. In contrast to the sample of firms outside of California, where polluters significantly outperformed non-polluters, in the post-election period, Californian polluters did not outperform Californian non-polluters. This differential performance of the Californian climate risk hedge portfolio is consistent with California's announcement to continue working toward meeting the targets of the global climate accord and suggests that state-level regulation can act as an effective substitute for federal level regulations.

Our third test considers a sample of non-US firms that are listed on US stock markets and for which we have a climate risk exposure score based on these firms' 20-F forms. For this sample of 678 non-US firms, we form a climate risk hedge portfolio that, for each of the 48 Fama French industries, has a long position in the one-third of companies with the highest climate risk exposure and a short position in the one-third of the companies with the lowest climate risk exposure. Because they are not subject to the same regulations, we expect to find no or smaller abnormal returns around the two events related to the Trump government. Results for the three different factor models are in Table 4, Panels A-C.

For the sample of non-US firms, the hedge portfolio of polluters versus non-polluters around the signing of the Paris agreement yields a significant negative return of around −0.5% for the market model and the 3-factor model (*p*-value is 0.01 for both) and is negative −0.2% but insignificant using the 4-factor model. President Trump's election results in a value increase for firms with a high score on climate risk, but the cumulative abnormal return is only significant for the market model. The results indicate that non-US polluters were disadvantaged by the actual policies of the Trump government, with cumulative abnormal returns on the hedge portfolio of around −10% (*p*-values range from 0.01 to 0.03).

5. Additional tests following AFAANZ 2018 Meeting

Based on feedback received from participants at the "Ball and Brown, 1968- Special Issue" at the 2018 AFAANZ conference, we included a number of additional robustness tests.

5.1. Additional test 1: WordCount instead of ClimateRisk

As discussed previously, our measure of firm-specific exposure to climate risk is based on textual analysis of 10-K disclosures and considers both the length of climate change related disclosures in company 10-Ks and the specificity of the language used. In the first additional test we use *WordCount*, the number of words in climate change related disclosures in a company's 10-K, instead of *ClimateRisk*, which also considers the specificity of the language used.

[10] We only present the results for the four-factor model. Conclusions based on the results of the market model and 3-factor model are similar.

Table 4
Regression results for the daily hedge portfolio based on climate risk measure for Non-US firms traded in US markets.

	(A) Market model		(B) FF3		(C) FF4	
	Est.	*p*-value	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.56	0.000	0.37	0.000	0.39
ParisIN	−0.005	0.01	−0.005	0.01	−0.002	0.15
Election	0.009	0.06	0.002	0.59	0.001	0.82
Inauguration/ParisOUT	−0.116	0.01	−0.084	0.03	−0.093	0.02
MKTRF	−0.017	0.56	−0.030	0.34	−0.066	0.05
SMB			0.040	0.27	−0.024	0.45
HML			0.218	0.01	0.115	0.01
MOM					−0.195	0.01
Adj R2	0.014		0.081		0.186	

Notes: Table 4 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the one third of Non-US companies traded in US markets with the highest climate risk exposure for each of the Fama-French 48 industries and a short position in the one third of the companies with the lowest climate risk exposure portfolio for each of the 48 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Panels A-C, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

We follow the same procedure as before but now examine the performance of the portfolio that has a long position in the one third of companies with the highest *WordCount* for each of the Fama and French 48 industries and a short position in the one third of the companies with the lowest *WordCount* for each of the 48 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Table 5, Panels A-C, respectively.

The results in Table 5 show that the election of Trump is the only event with a significantly different reaction between firms with a high *WordCount* and firms in the same industry with a low *WordCount*. Comparing the results in Table 2 and Table 5, it is clear that *ClimateRisk* is a more informative variable than *WordCount*, which shows the importance of having a text-based measure that gives a higher score to language that is more directly relevant to climate change.

Table 5
Regression results for the daily hedge portfolio based on the length of climate risk related excerpts.

	(A) Market model		(B) FF3		(C) FF4	
	Est.	*p*-value	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.56	0.000	0.56	0.000	0.56
ParisIN	−0.001	0.67	0.000	0.87	0.000	0.87
Election	0.014	0.01	0.013	0.01	0.013	0.01
Inauguration/ParisOUT	0.023	0.42	0.024	0.40	0.024	0.40
MKTRF	−0.128	0.01	−0.134	0.01	−0.134	0.01
SMB			0.056	0.06	0.056	0.06
HML			0.003	0.91	0.003	0.91
MOM					0.000	0.99
Adj R2	0.105		0.111		0.111	

Notes: Table 5 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the one third of companies with the highest word count for each of the Fama-French 48 industries and a short position in the one third of the companies with the lowest word count for each of the 48 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Panels A-C, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

5.2. Additional test 2: Tone instead of ClimateRisk

In a further test, we use a variable that captures the *Tone* of the climate change related disclosures in a company's 10-K, instead of *ClimateRisk*. Based upon the word dictionary in Loughran and McDonald (2011), we measure the number of positive and negative words included in the climate risk-related 10-K extracts.[11] *Tone* is defined as the difference between the total number of positive words and the total number of negative words. Hence a lower value for *Tone* corresponds to a higher exposure to climate change risk.

We follow the same procedure as before but now examine the performance of the portfolio that has a long position in the one third of companies with the highest *Tone* for each of the Fama and French 48 industries and a short position in the one third of the companies with the lowest *Tone* for each of the 48 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Table 6, Panels A-C, respectively.

The results in Table 6 are generally consistent with our expectations. The Paris Agreement on Climate Change (*ParisIN)* resulted in an increase in value of firms with a high score on *Tone* ("non-polluters") versus firms in the same industry with a low score on *Tone* ("polluters"). The cumulative abnormal return on the climate risk hedge portfolio during the 3-day window is around 0.8%, significant at the 10% level. The election of Donald Trump as president of the U.S. (*Election)* resulted in a significant value decrease of the non-polluting firms relative to same-industry polluters of between 0.4 and 1% (*p*-values range from 0.06 to 0.01). The period between the inauguration through to the withdrawal from the Paris agreement (*Inauguration/ParisOUT)* saw a further value increase for polluters relative to same-industry non-polluters of around 6 to 9% (*p*-values range from 0.01 to 0.06).

5.3. Additional test 3: only industries with positive median ClimateRisk

The results in Table 1 show that 15 out of the 48 Fama-French industries have median values of *ClimateRisk* of 0. These industries are Aircraft, Banking, Business Services, Communication, Computers, Goods, Electronic Equipment, Healthcare, Measuring and Control Equip., Medical Equipment, Personal Services, Pharmaceutical Products, Printing and Publishing, Recreation, Trading. With the possible exception of the Aircraft industry, it is likely that the low value of *ClimateRisk* for these industries indicates a perceived absence of material risk of climate change for the majority of firms in these industries. To explore the impact on our results of these industries with immaterial risk of climate change, we rerun our main test, but now exclude firms from industries with a median score on *ClimateRisk* of 0.

We follow the same procedure as before and examine the performance of the portfolio that has a long position in the one third of companies with the highest *ClimateRisk* for each of the remaining 33 industries and a short position in the one third of the companies with the lowest *ClimateRisk* for each of the remaining 33 Fama-French industries. The results for the market model, the Fama-French three-factor model and the four-factor model are in Table 7, Panels A-C, respectively.

The results in Table 7 are similar to the results for the full sample in Table 2. While the cumulative abnormal returns on the hedge portfolio are larger in magnitude around the Paris Agreement on Climate Change (*ParisIN)* and in the period between the inauguration through to the withdrawal from the Paris agreement (*Inauguration/ParisOUT)*, the cumulative abnormal returns on the hedge portfolio are smaller in magnitude around the election of Donald Trump as president of the U.S. (*Election)*.

5.4. Additional test 4: US hedge portfolio vs. Non-US hedge portfolio

The results in Table 2 and Table 4 show that both US and non-US firms with a high score on *ClimateRisk* experienced a similar relative value drop relative to firms with a low score around the signing of the Paris agreement. However, around the election and in the period after the inauguration, US polluters significantly outperformed US non-polluters, whereas for non-US firms we observed no value change in the hedge portfolio around the election and a value drop during the first 6 months of the Trump administration.

In this test, we construct a hedge portfolio that longs the US hedge portfolio (used in Table 2) and shorts the non-US hedge portfolio (used in Table 4). The results in Table 8 confirm that the US and non-US hedge portfolios displayed a similar reaction to the signing of the Paris agreement. We also observe outperformance of the US hedge portfolio in the election time period of around 1%, for both the 3- and 4-factor models (both significant at the 5% level). Outperformance of the US hedge portfolio during the first 6 months of the Trump administration is more than 10% (significant at the 1% level for all three models), indicating a significant value increase in US polluters relative to non-US polluters as a result of the policies adopted during the first 6 months of the Trump administration.

6. Discussion and conclusion

We examine the impact of government commitment to combating climate change on firm value. We expect that as governments signal increased commitment, the stock market will anticipate increases in regulatory costs for companies that face greater climate risk and will correspondingly reduce firm market value. Similarly, we expect that decreases in governmental commitment will be viewed more positively for companies that face greater climate risk because of a reduction in expected regulatory costs. This is particularly interesting, because the nature of climate risk differs greatly across firms and across industries.

[11] Loughran and MacDonald's (2011) negative (positive) word list is restricted to include only words that typically have negative (positive) implications in a financial sense.

Table 6
Regression results for the daily hedge portfolio based on the tone of climate risk related excerpts as per Loughran and McDonald (2011).

	(A)		(B)		(C)	
	Market model		*FF3*		*FF4*	
	Est.	*p*-value	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.31	0.000	0.47	0.000	0.45
ParisIN	0.008	0.08	0.007	0.08	0.008	0.07
Election	−0.004	0.06	−0.010	0.01	−0.010	0.01
Inauguration/ParisOUT	−0.089	0.01	−0.059	0.06	−0.061	0.05
MKTRF	0.123	0.01	0.112	0.01	0.105	0.01
SMB			0.024	0.35	0.011	0.66
HML			0.210	0.01	0.190	0.01
MOM					−0.039	0.02
Adj R2	0.121		0.234		0.242	

Notes: Table 6 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the one third of companies with the highest tone for each of the Fama-French 48 industries and a short position in the one third of the companies with the lowest tone for each of the 48 Fama-French industries. Tone is defined as the difference between the total number of positive words and the total number of negative words, based upon the word dictionary in Loughran and McDonald (2011). We measure the number of positive and negative words included in the climate risk-related 10-K extracts. The results for the market model, the Fama-French three-factor model and the four-factor model are in Panels A-C, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

Table 7
Regression results for the daily hedge portfolio based on climate risk measure for 33 Industries with positive median *ClimateScore.*

	(A)		(B)		(C)	
	Market model		*FF3*		*FF4*	
	Est.	*p*-value	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.83	0.000	0.83	0.000	0.80
ParisIN	−0.009	0.01	−0.010	0.01	−0.010	0.01
Election	0.006	0.01	0.007	0.01	0.008	0.01
Inauguration/ParisOUT	0.052	0.02	0.050	0.03	0.052	0.02
MKTRF	−0.149	0.01	−0.143	0.01	−0.136	0.01
SMB			−0.049	0.05	−0.036	0.14
HML			−0.007	0.77	0.014	0.62
MOM					0.039	0.01
Adj R2	0.189		0.196		0.206	

Notes: Table 7 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the one third of companies with the highest climate risk exposure for each of the Fama-French 48 industries and a short position in the one third of the companies with the lowest climate risk exposure portfolio for each of the 48 Fama-French industries. The sample includes only industries with a positive median climate risk score. The results for the market model, the Fama-French three-factor model and the four-factor model are in Panels A-C, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

Finding results consistent with our expectations requires that the market impounds expected regulatory costs. Prior research indicates that markets respond to increased regulation (e.g., Larcker et al., 2011), as well as expectations about enforcement of new regulations (e.g., Berkman et al., 2010). Rather than examining specific regulations, our study focuses on expected regulation, with expected (albeit unspecified) changes in regulatory costs when the government changes its level of commitment to enacting/enforcing agreements for addressing climate risk.

Much of the research on expected regulatory costs associated with environmental issues has focused on specific environmental events. Blacconiere and Patten (1994) find that although the 1984 Bhopal chemical leak was specific to Union Carbide, there was a

Table 8
Regression results for US daily hedge portfolio vs. non-US daily hedge portfolio.

	(A)		(B)		(C)	
	Market model		*FF3*		*FF4*	
	Est.	*p*-value	Est.	*p*-value	Est.	*p*-value
Intercept	0.000	0.66	0.000	0.42	0.000	0.45
ParisIN	0.001	0.77	0.001	0.46	−0.003	0.09
Election	−0.001	0.87	0.010	0.02	0.012	0.01
Inauguration/ParisOUT	0.160	0.01	0.114	0.01	0.126	0.01
MKTRF	−0.042	0.20	−0.019	0.59	0.027	0.44
SMB			−0.101	0.02	−0.019	0.61
HML			−0.310	0.01	−0.178	0.01
MOM					0.251	0.01
Adj R2	0.017		0.113		0.233	

Notes: Table 8 presents results for a zero-cost hedge portfolio over a two-year period starting on 1 June 2015 and ending on 30 June 2017 ($N = 526$). The portfolio has a long position in the US hedge portfolio (used in Table 2) and has a short position in the non-US portfolio (used in Table 4). The results for the market model, the Fama-French three-factor model and the four-factor model are in Panels A-C, respectively. *ParisIN*, *Election*, and *Inauguration/ParisOUT*, are variables which assume values of 1/3, 1/3 and 1/93 during the respective event periods, and zero otherwise. The first factor, *MKTRF*, is the market excess return. The second and third factors, *SMB* and *HML*, represent the differences in returns between portfolios of small and large firms (*SMB*) and the differences in returns between portfolios of high and low book-to-market ratios (*HML*) (see Fama and French, 1993). The fourth factor (*MOM*) is the momentum factor and represents the difference in returns between past winners and losers (see Carhart, 1997). The intercept in Eq. (1) measures the average daily return of the hedge portfolio relative to the four factors and after accounting for the impact of the events. *P*-values are based on Newey-West standard errors.

general negative stock market reaction for companies in the chemical industry. Other studies find evidence that market valuations are affected by the degree to which companies are expected to be impacted by increased regulation. Bowen et al. (1983) find that the stock market reaction to the 1979 Three Mile Island nuclear accident was negatively associated with utility participation in nuclear energy. In the Chinese setting, Li et al. (2017) find that increases in expected regulatory costs stemming from a historically high level of pollution, subsequent media outrage and governmental discussion of climate change varied based upon firm characteristics, such as whether the firm was a State-Owned Enterprise or a member of a polluting industry. In their study, the negative impact of increased expected regulatory costs persisted over time, with lasting reductions in market valuations subsequent to the events.

Anticipated regulations should be already incorporated into stock market prices (Schwert, 1981). Binder (1985) notes that that formal regulatory announcements are generally anticipated and it is frequently difficult to determine when expectations change. As a result, there is typically little stock market reaction at the time of regulation. It is therefore important that we examine events that are unanticipated and change market expectations of future regulatory costs. We examine three events related to the US Federal Government's commitment to climate change: 1) Passage of the Paris Agreement on Climate Change; 2) Election of Donald Trump as US President; and 3) the time period from Trump's election until he caused the US to withdraw from the Paris Agreement.

Each of these events poses an unanticipated change in market expectations about the US government's commitment. The first event signals an unanticipated increase in government commitment to climate change. While there was a prolonged discussion and negotiation for development of the Paris Agreement, with agreed-upon deadlines, whether the US would join the agreement was unclear until the last minute. Indeed, US cooperation was not gained until after the deadline, when language that would require the US to provide resources to poor countries was softened to make such contributions voluntary.[12]

The second and third events signal unanticipated declines in the US government's commitment to climate change. Election of climate change denier Donald Trump was unexpected, as it was contrary to the majority of polls going into the election. As president, his choice of Scott Pruitt (another climate change denier) to be Administrator of the Environmental Protection Agency (EPA), announcement of budget cuts for the EPA, and his eventual withdrawal from the Paris Agreement all signal a reduction in US government commitment to addressing climate change. While it was clear that Trump was against combating climate change, the extent of his commitment and active strategy against doing so was unanticipated.

Using a measure of climate risk derived from 10-k disclosures (Berkman et al., 2018), we build a hedge portfolio that is long in US companies that have high levels of climate risk and short in US companies that have low levels of climate risk. We find a significant −0.5% abnormal return around signing of the Paris agreement, a significant 1% abnormal return around the election of President Trump and a further positive abnormal return of around 4% following his inauguration. These results are consistent with the market pricing government commitment to combating climate change and provide support for use of our firm-specific measure of climate risk.

When we build a similar hedge portfolio comprised of non-US firms, results are quite different. The non-US portfolio also experienced a negative return around the signing of the Paris agreement, which is consistent with changes in commitment to combating climate change for governments outside of the US. Because these firms are not subject to US government policies related to climate

[12] See https://www.nytimes.com/interactive/projects/cp/climate/2015-paris-climate-talks/at-climate-talks-three-letters-almost-sunk-the-deal

change we do not expect and do not find evidence of a reaction to the US election for the non-US hedge portfolio, however. Further, in contrast to the US hedge portfolio, we find a relative value *decrease* in reaction to policies announced in the first 6 months of the Trump administration. This may due to a competitive disadvantage for companies outside of the US, who will be subject to regulatory costs associated with combating climate change in their home jurisdictions.

Finally, we find evidence that even if there is a decline in support for combating climate change at the Federal level, countervailing regulations at other levels of government may usurp the Federal regulatory strategy. Of all states in the US, California has the most stringent environmental regulations. Further, as the Trump government continued to reduce US commitment to combating climate change, California officials actively pursued legislation that would support achievement of targets under the Paris Agreement. Consistent with Californian commitment to combating climate change making up for the lack of commitment at the Federal level, our results indicate that the increase in value for the US hedge portfolio is primarily driven by non-Californian firms. These results underscore the need to take into consideration countervailing regulations at other levels of government that may undermine governmental regulatory intentions.

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References

Ball, R., Brown, P., 1968. An empirical evaluation of accounting income numbers. J. Account. Res. 6, 159–178.
Beaver, W.H., 1968. The information content of annual earnings announcements. J. Account. Res. 67–92.
Berkman, H., Cole, R.A., Fu, L.J., 2010. Political connections and minority-shareholder protection: evidence from securities-market regulation in China. J. Financ. Quant. Anal. 45, 1391–1417.
Berkman, H., Jona, J., Soderstrom, N.S., 2018. Measurement and Market Valuation of Climate Risk. Available at SSRN: https://ssrn.com/abstract=2775552.
Binder, J.J., 1985. Measuring the effects of regulation with stock price data. RAND J. Econ. 167–183.
Blacconiere, W.G., Patten, D.M., 1994. Environmental disclosures, regulatory costs, and changes in firm value. J. Account. Econ. 18, 357–377.
Bowen, R.M., Castanias, R.P., Daley, L.A., 1983. Intra-industry effects of the accident at three Mile island. J. Financ. Quant. Anal. 18, 87–111.
Campbell, J.L., Chen, H., Dhaliwal, D.S., Lu, H.-m., Steele, L.B., 2014. The information content of mandatory risk factor disclosures in corporate filings. Rev. Acc. Stud. 19, 396–455.
Campbell, J.Y., Lo, A.W.-C., MacKinlay, A.C., 1997. The Econometrics of Financial Markets. Princeton University Press.
Carhart, M.M., 1997. On persistence in mutual fund performance. J. Financ. 52, 57–82.
Chandler, D., 2017. Strategic Corporate Social Responsibility: Sustainable Value Creation. Sage Publications.
Fama, E.F., French, K.R., 1993. Common risk factors in the returns on stocks and bonds. J. Financ. Econ. 33, 3–56.
Gsia, G.S.I.A., 2015. Global Sustainable Investment Review 2014. (Febbraio).
Johnson, C., 2017. The Trump administration is taking on drug prices—But not drug companies, in: Post, T.W. (Ed.), The Washington Post.
Larcker, D.F., Ormazabal, G., Taylor, D.J., 2011. The market reaction to corporate governance regulation. J. Financ. Econ. 101, 431–448.
Li, C.K., Luo, J.-h., Soderstrom, N.S., 2017. Market Response to Regulatory Costs Related to Haze. Working Paper Available on. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2777455.
Loughran, T., McDonald, B., 2011. When is a liability not a liability? Textual analysis, dictionaries, and 10-Ks. J. Financ. 66, 35–65.
Schwert, G.W., 1981. Using financial data to measure effects of regulation. The Journal of Law and Economics 24, 121–158.
Sefcik, S.E., Thompson, R., 1986. An approach to statistical inference in cross-sectional models with security abnormal returns as dependent variable. J. Account. Res. 24, 316–334.